ACCELERATED SITE TECHNOLOGY DEPLOYMENT PROGRAM

Monitoring and Verification of Tank In Situ Vitrification

J U N E • 1 9 9 8

INEEL

IDAHO NATIONAL ENGINEERING & ENVIRONMENTAL LABORATORY

United States Government **Department of Energy**

memorandum

Idaho Operations Office

Date: June 12, 1998

Subject: Submittal of Accelerated Site Technology Deployment Proposal - (LD-98-189)

To: James R. Wade, Director
Accelerated Site Technology Deployment Program
DOE-ID, OPE, MS-1235

In response to the Accelerated Site Technology Deployment (ASTD) call for proposals, dated May 1, 1998, we are pleased to submit the ASTD proposal “Monitoring and Verification of Tank In Situ Vitrification.” This proposal has the full support of both the Office of Laboratory Development and Office of Program Execution at the U.S. Department of Energy Idaho Operations Office (DOE-ID). Implementation of the project described in the proposal will enhance our Environmental Management capabilities and the ability of the Idaho National Engineering and Environmental Laboratory to meet its priority regulatory commitments.

DOE-ID is confident that the Idaho National Engineering and Environmental Laboratory has the ability to implement the technology approach described in the proposal within current funding levels and schedules.

We look forward to working with the ASTD Program and are eager to begin this deployment effort.

Kathleen E. Hain, Director
Environmental Restoration

Jerry L. Lyle, Assistant Manager
Office of Program Execution

Attachment

cc: W. E. Bergholz, MS-1203
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Executive Summary

Recent treatability studies and demonstrations have made In Situ Vitrification (ISV) the preferred treatment for Tanks V-1, V-2, V-3, and V-9 located at Test Area North (TAN). ISV is the chosen method because it is a Toxic Substance Control Act (TSCA) licensed method of treating polychlorinated biphenyl-contaminated mixed waste. In order to implement ISV at TAN, a means of mapping the melt boundaries and the elevated temperature zone around the melt is needed to verify the extents and the quality of the melted area.

The baseline method of monitoring and verifying ISV melts is to use many sample holes with thermocouples around and under the melt area along with coring of the ISV monolith. The area where these tanks are located is relatively confined and contains many man-made above and below grade structures including a building approximately 8 feet from V1, V2, and V3. The soils around the tanks are also contaminated with radioactive and chemical wastes. Combined, these conditions make conventional monitoring of ISV processes difficult and cost prohibitive. In addition, the confined surroundings limit potential placement of the thermocouples beneath the tanks via horizontal drilling. A means of verification and monitoring that reduces the need for many sampling holes would significantly improve the implementability of ISV for tanks at TAN. The verification and monitoring system proposed here combines limited sample holes (containing chemical sampling ports and moisture sampling port along with thermocouples) with nonintrusive an minimally intrusive geophysical methods that noninvasively map the resultant melt boundaries and isotherm location during and after the ISV process. While this monitoring and verification system is being proposed for the TAN V tanks, it is also applicable to other, future ISV treatments at the Idaho National Engineering and Environmental Laboratory (INEEL) Subsurface Disposal Area (SDA), Oak Ridge National Laboratory and Savannah River Site.

This approach combines a number of commercially available technologies in an innovative manner to deliver a stronger verification tool than has generally been available for monitoring ISV melts. This system of monitoring and verification was demonstrated by the Office of Science and Technology (EM-50) in FY-97 during the INEEL SDA Acid Pit in situ stabilization treatability study.

Approximately \$190K is requested from the Accelerated Site Technology Deployment (ASTD) Program and the INEEL Environmental Restoration Program will contribute approximately \$196K as co-funding. Implementation of the proposed system offers a cost savings of \$430.7K over the baseline, this produces a return on investment of 2.27 for the ASTD Program.

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TABLES

Screening Criteria Assessment

	Screening Criteria	Referenced Page(s)	To Be Filled Out By Selection Committee Only Did Proposal Meet This Criteria? (Yes/No)
1	The end-user need, as identified through the Environmental Management (EM) Integration disposition maps and/or outlined in *Accelerating Cleanup: Paths to Closure*. (Needs not identified within these documents must provide clear, concise justification for further evaluation.)	pg 2, par 5	
2	A completed cost benefit analysis has been submitted comparing a detailed cost estimate of the proposed technology or process against a validated cost estimate of the baseline technology or process.	pg 5, Table 1 pg 6, Table 2 pg 6, Table 3	
3	The proposal is not requesting funds for a demonstration, but for technology deployment.	pg 2, par 2	
4	Joint funding or in-kind contributions of at least 50% of the project costs are provided by the proposing organizations, including 25% in the first year.	pg 6, par 1	
5	The proposal provides a written commitment from the proposing DOE Site Manager, Site Assistant Manager of EM, or equivalent with the budget authority.	memo, pg iii	

NOTE: *Sidebars placed throughout the text indicate where screening criteria have been met. The number next to the bar references the appropriate criteria.*

1.0 Introduction and Background

The Test Area North (TAN) V-tank site is a small and confined area with numerous subsurface structures, pipes and power conduits situated adjacent to each of the four polychlorinated biphenyl (PCB)-contaminated V-tanks. The site is located between multiple contaminated buildings, including TAN 616 (located approximately eight feet from V1, V2, and V3), TAN 615 (16 feet from Tank V-30 and TAN 607 (16 feet from Tank V-9). Furthermore, the soils surrounding the tanks are contaminated with radioactive cesium, transuranic (TRU) radionuclides, other low-level waste (LLW) radionuclides, and may also be contaminated with other hazardous compounds from the wastes in the tanks. All of these site conditions, make excavation or extensive drilling around the tanks cost prohibitive and hazardous to the personnel working in the area. Thus, in order to perform In Situ Vitrification (ISV) treatment of the tanks a means of monitoring the melt progression and verifying the melt boundaries must be used that is cost-effective and can be operated in a cluttered, contaminated area with minimal worker risk.

The temperature distribution around the melt is a parameter that needs to be measured for three reasons. First, the melt and temperature front must be measured in relation to the buildings around the tanks. The location of the 100-degree isotherm and the melt front need to be located to assure minimal interaction with any structure not included in the ISV processing (including adjacent buildings). Second, because the tanks will be vitrified in succession with a short pause between each tank melt, it is important to know the temperature distribution within the melt to assure that adequate electrical conductivity is still present between the electrodes in each melt plane. Finally, the total extent of the melt needs to be verified along with the location of the melted metal from the tank to verify that the treatment objectives have been met. This last verification requirement is usually accomplished by mapping the temperature growth and core data. We are proposing to combine limited thermocouple data with nonintrusive geophysical methods, and sampling instrumentation to monitor and verify the melt process.

2.0 Part I — Technical Proposal Overview

2.1 Impact/Technical Approach

Mapping of the temperature distribution and the melt extents is typically accomplished by placing many (>150) thermocouples around and under the melt area. The lateral extents of the melt area are typically inferred from the isotherm data and process data. The vertical depth of the melt zone is inferred using the final depth of the electrodes and the metal zone is conservatively inferred from process parameters. These thermocouples are installed using drill holes around and under the melt in 15 or more boreholes. Often horizontal drilling methods are required to place select thermocouples under the melt in an orientation that does not lead to premature failure, due to the thermocouple sheath melting away from the thermocouple junction point. This is expensive, difficult, and could be hazardous in the area. Horizontal drilling to place thermocouples under the melt may not be feasible due to the confined area of operation, the unknown location of many underground pipes, powerlines, and other underground structures around the tanks. The risk of contamination to the drill crew is also significant, not only from the soils but also from the possibility of breaching a contaminated pipe or crib during drilling.

We are proposing to perform a series of surface and borehole geophysical surveys taken during the course of the cool-down in conjunction with limited thermocouple and other sampling data to determine the locations of the 100-degree isotherm, the melt-unmelted region and the metal zone at the bottom of the melt. The system we are proposing was demonstrated in FY-97 by the Office of Science and Technology (OST) (EM-50) during the Acid Pit treatability study conducted at the Idaho National Engineering and
3 Environmental Laboratory (INEEL) Subsurface Disposal Area (SDA). This method will provide a means of verifying the melt region with minimal worker exposure during to the verification and monitoring effort. The techniques we are proposing to use are electromagnetic induction, ground penetrating radar, shear wave seismic profiling across the area, and tomographic imaging along with passive seismic monitoring to augment thermocouple data collected in two to three 3
boreholes and in near surface (less than 2 feet) locations. The two boreholes will also be instrumented with lysimeters, tensiometers and volatile organic compound (VOC) sampling devices and also be used for hole-to-hole geophysical investigation.

Electromagnetic methods can detect the 100-degree isotherm due to the change in electrical conductivity between the wet soil and the soil containing water vapor (steam). The melt region is also highly electrically conductive until solidified so that the boundary of the melt zone can also be determined during the course of cool-down using electromagnetic induction techniques. The melt region will also display shear wave attenuation until it is solidified and shear wave techniques will be used to map the melt region during cool-down. Finally, after the melt has cooled and hardened, we will use ground penetrating radar to map the vertical extents of the melt, and map the extents of the metal zone at the bottom of the vitrified area.

The soil moisture and vapor sampling, soil moisture content measurements and soil tension measurements will be used in conjunction with the geophysical data to map the distribution of moisture and contaminants around the melt region along with mapping the 100-degree isotherm and ISV extents.

By collecting samples of VOCs, moisture data, and geophysical data during and after ISV melting, the rate of growth of the 100-degree isotherm can be mapped along with any increases in moisture or VOCs encountered in the boreholes. This data can be used to understand the migration of moisture and contaminants around the ISV melt. Thus, this proposal directly supports Site Technology Coordination Group (STCG) need ID-6.1.24 1
"*Understanding the Migration of VOCs Around an ISV Melt*." The technology deployed during the

V-tank ISV is applicable to any form or application of ISV and the results will provide the preliminary understanding of VOC migration needed for ISV acceptance at the INEEL SDA. The technology deployed can also be used at the SDA, and other Department of Energy (DOE) sites (such as Savanna River Site and Oak Ridge National Laboratory) to provide the necessary verification and monitoring of the ISV melt process.

The proposed system is an improvement over the baseline verification and monitoring system in two important ways. First, the system provides information on fluid, vapor, and contaminant concentration and movement that is not available from using thermocouples. Second, the system reduces worker exposure to hazardous conditions and costs associated with drilling in a contaminated area.

2.2 Business/Management Approach

Please refer to page iii for a letter of commitment from the INEEL Environmental Restoration Program to implement this technology.

The deployment of this verification and monitoring system will be performed in three phases. Phase 1 is the initial planning for the survey. This phase includes writing all workplans, safety plans permitting and testplans needed and is expected to take 4.5 months to complete. Phase 2 is drilling and instrumenting the wells and is anticipated to take. This 3 weeks to complete. The third phase is borehole data collection, nonintrusive sampling during and after the ISV melt process. This phase will be ongoing at a total level of effort until after the melt cools and hardens. Interpretation and reporting are included in this phase. This last phase is expect to take 7 months to complete but may require longer monitoring to achieve verification goals.

Proposal Team. The management structure for this proposal will be under the control of Ms. Kathleen Hain, the Federal program manager with operational responsibility for the INEEL Environmental Restoration Program (see page iii for written commitment). Ms. Hain has overall responsibility for and authority to commit the necessary facilities and resources to this project. Formal communications, filed offices and the Accelerated Site Technology Deployment (ASTD) Program are the responsibility of Ms. Hain. The LMITCO Environmental Restoration Operation Director, Ms. Kathy Falconer, has full authority to command necessary resources within Lockheed Martin Idaho Technology Company (LMITCO) to execute the project. Waste Area Group Manager, Mr. Doug Greenwell is responsible for execution of all technical and facility activities necessary to implement this project.

Team Commitment. Commitments provided by the INEEL deployment team and industrial technology providers demonstrate a willingness and desire to solve the DOE Environmental Management (EM) issues through this technology deployment. Unique to this technology deployment is the commitment by the EM-30 to utilize the deployment in their operations.

2.3 Stakeholder/Regulatory

After drilling and installation of the boreholes is complete, all the remaining work will be nonintrusive and gas samples collected will be analyzed at the boreholes eliminating sample generation. All health and safety plans and documentation, work outages, workplans, testplans and work permits will be obtained prior to drilling at TAN. Hazardous waste generation will be minimal but a waste management plan will be put in place. These steps will follow those used at the INEEL to drill at hazardous sites. All TAN health and safety training and protocols will be strictly followed.

The INEEL's stakeholder and regulatory approach ensures that all regulators, stakeholders, and tribes are active participants in the planning and implementation of programs that affect the local community and the larger public effected by DOE Complex-wide issues. DOE Idaho Operations Office (-ID) and its Management and Operations contractor, LMITCO, have established a rigorous systems engineering process for public participation that facilitates identification, documentation, and tracking of issues and requirements in conjunction with the stakeholders. This systems engineering process has proven effective for projects and programs similar to the effort proposed.

Through the INEEL's regulatory and stakeholder process, in conjunction with the state, EPS, tribes, citizens' groups, and other stakeholders, these projects have received the necessary approvals for implementation at the INEEL. The process used in these projects follows the approaches recommended by the Western Governors Association and approved by stakeholders.

They include:

- Integrate technical and nontechnical processes at strategic decision-making points
- Use a team approach to project coordination
- Take the process directly to all interested players
- Provide top-level management support and adequate funding
- Provide for all accountability to the public.

A key element and approach to the INEEL stakeholder program is the Stakeholder Participation Plan. This plan provides a mechanism for stakeholders to be involved in the proposed INEEL technology deployment, to the maximum extent feasible, giving opportunities to impact decision-making throughout the process. The purpose of this stakeholder plan is to guide the process for achieving full and effective stakeholder participation, while at the same time using existing INEEL stakeholder groups to the greatest degree possible.

The INEEL is committed to providing all of our capabilities and the capabilities of our commercial partners, to integrate across site and state barriers for successful future deployment of this system at other sites.

The INEEL deployment team is experienced in gaining regulatory approval through a rigorous systems engineering process of identifying applicable or relevant and appropriate requirements and required permits, planning to meet requirements and obtain permits, and successfully obtaining regulatory approvals and permits.

3.0 Part II — Cost Overview

3.1 Cost Benefit Analysis

The baseline method required to monitor and verify the ISV process and resulting melt is the placement of a large number of thermocouples and the drilling of a large number of boreholes. The life-cycle cost of utilizing this method is detailed in Table 1. The baseline cost estimate is broken into three functional areas as follows; the vertical drilling of 20 holes ($574.9K), the horizontal drilling of one hole ($163.5K), and the data acquisition costs ($78K), for a total baseline cost of $816.5K.

The system proposed for the verification and monitoring of the ISV melting of the TAN V-Tanks is a combination on nonintrusive and minimally intrusive technologies that have the ability to detect the growth of the temperature distribution around the melt and detect zones within the melt (radar, seismic, electromagnetic surveys). The life-cycle cost of utilizing this system is detailed in Table 2. The proposal cost

Table 1. Current baseline pricing proposal form.

Scope	*Total Hours*	*Labor Rate*	*Labor Cost*	*Nonlabor Cost*	*Total Cost*
Vertical Drilling Costs 20 Holes					
Site access and planning*	2,240	65	145,600	—	145,600
Drillers (2)	2,000	65	130,000	—	130,000
RadCon engineer	1,000	65	65,000	—	65,000
Support personnel (2)	2,000	65	130,000	—	130,000
Decontamination of drill rig	120	65	7,800	—	7,800
Instrumentation installation	1,000	75	75,000	—	75,000
Procurement of instruments	—	—	—	20,000	20,000
Miscellaneous supplies	—	—	—	1,500	1,500
Total Vertical Drilling Costs			553,400	21,500	574,900
Horizontal Drilling Costs 1 Hole					
Site access and planning	100	65	6,500	—	6,500
Drillers (2)	100	65	6,500	—	6,500
2 RadCon engineer	50	65	3,250	—	3,250
Support personnel (2)	100	65	6,500	—	6,500
Decontamination of drill rig	120	65	7,800	—	7,800
Instrumentation installation	100	75	7,500	—	7,500
Instrument procurement	—	—	—	500	500
Drill rig services	—	—	—	25,000	25,000
Possible procurement of rig	—	—	—	100,000	100,000
Total Horizontal Drilling Costs			38,050	125,500	163,550
Data Acquisition					
Data collection costs					
Sample borehole instruments	120	75	9,000	—	9,000
Data interpretation	240	75	18,000	—	18,000
Reporting	160	75	12,000	—	12,000
Total data collection costs	—	—	39,000	—	39,000
Total Data Acquisition Costs			78,000		78,000
TOTAL COST			**669,450**	**147,000**	**816,450**

* Includes all permitting and health and safety plans.

**All rates are fully burdened rates.

Table 2. ASTD cost estimate pricing proposal form.

Scope	*Total Hours*	*Labor Rate*	*Labor Cost*	*Nonlabor Cost*	*Total Cost*
Vertical Drilling Costs 2 to 3 Holes					
Site access and planning	720	65	46,800	—	46,800
Drillers (2)	40	65	2,600	—	2,600
RadCon engineer	20	65	1,300	—	1,300
Support personnel (2)	40	65	2,600	—	2,600
Decontamination of drill rig	120	65	7,800	—	7,800
Instrumentation installation	20	75	1,500	—	1,500
Procurement of instruments	—	—	—	30,000	30,000
Miscellaneous supplies	—	—	—	1,500	1,500
Total Drilling Costs			62,600	31,500	94,100
2 **Nonintrusive Geophysics and Data Collection From Boreholes**					
Site access planning	180	65	11,700	—	11,700
RadCon support	200	65	13,000	—	13,000
Support personnel (2)	200	65	13,000	—	13,000
Data collection by subcontractor*	—	—	—	120,000	120,000
Sample borehole instruments	120	75	9,000	—	9,000
Data interpretation	400	75	30,000	—	30,000
Equipment rental	—	—	—	50,000	50,000
LMITCO contract costs	—	—	—	45,000	45,000
Reporting	200	75	15,000	—	15,000
Total Data Acquisition Costs			76,700	215,000	291,700
TOTAL COSTS			**139,300**	**246,500**	**385,800**

* Contractor costs are estimated using industry standards.

**All rates are fully burdened rates.

estimate is broken into two functional areas (no horizontal drilling is required) as follows; vertical drilling of 2 to 3 holes ($94.1K), and implementation of the nonintrusive technologies ($291.7K). The total cost for implementation of
4 the proposed system is $385.8K, of this amount $190K is requested from the ASTD Program and $195.8K will be provided by INEEL Environmental Operations over a 2-year period. Of the $195.8K in co-funding provided by operations $146.8K will be provided in FY-99 and $49.0K will be provided in FY-00.

The amount requested from ASTD is $195.8K, the cost benefit derived by implementing the proposed system is a 2.27 return on investment as shown below in Table 3. Both the baseline and the proposed system costs are calculated based on implementation of the technology in FY-99 and complete project completion in FY-00.

Table 3. Return on investment.

	Fiscal Year ($K)		*Total ($K)*	
	FY-99	*FY-00*		
A. Original EM Baseline Costs	612.4	204.1	816.5	
B. Proposed Costs for Project	289.3	96.5	385.8	2
Cost Savings			430.7	
C. ASTD Portion of Proposed Costs	142.5	47.5	190.0	
Return on Investment			2.27	

3.2 Additional Cost Information

The relatively high cost of utilizing the baseline technologies is primarily attributed to the number of boreholes that must be drilled. In addition, the decontamination or procurement of the horizontal drill rig adds a significant cost. The baseline methods are very intrusive to the ISV melt and require a significant health and safety effort to mitigate the risks.

Implementation of the proposed system of radar, electromagnetic surveys and seismic will be accomplished through a solicited procurement (see Table 2). Utilization of the proposed system requires significantly less labor than the baseline system and can be performed through subcontract cheaper than purchasing the system directly.

INEEL base costs include labor, materials, fringe, and facility costs. Overhead burden includes general and administrative and overhead costs. General and administrative rate is 32.5% and overhead rates varies between 11% and 12%, depending on the organization. All rates can be found in *LMITCO FY-98 Planning Preparation Guidance*, Revision 8, Section 10, “Planning Rate Guidance.” Functional costs breakdown are 56% direct and 44% support consistent with the INEEL Paths to Closure.